JOURNAL OF ENGINEERING AND APPLIED SCIENCE, VOL. 67, NO. 4, AUG. 2020, PP. 829-846
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EVALUATION OF THE EFFICIENCY OF FOUR WATER PURIFICATION PLANTS IN BASRAH PROVINCE

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ABSTRACT

The evaluation of the treatment efficiency of four water purification plants in Basrah Governorate was carried out through laboratory tests to assess the effect of the different rivers feeding the plants on the treatment efficiency. Some physical and chemical properties were measured. The results showed that the quality and efficiency of the treated water was very low and unacceptable at the four plants. The results proved that the treated water samples of the plants are unsuitable for drinking. They also demonstrated that the imbalance in the low efficiency of the treatment was not only in the inability of the plants to treat dissolved salts in water, but there was also a significant deficiency in the plants ability to remove impurities and suspended substances, which is the core of the work and tasks of treatment plants. The discharge rates and salts concentrations over the last ten years feeding the Shatt al-Arab river were insufficient to contribute to a positive change in the water quality. A more sophisticated technique of water purification should be adopted, namely desalination in all plants of Basrah. This desalination technology should complement the treatment process after the purification process.

KEYWORDS: Water purification plants, treatment, efficiency, Basrah Governorate.

1. INTRODUCTION

The earth contains abundant quantities of water resources constituting almost 75% of the earth. Water is the basis for the life of man, animal, plant and all living organisms. However, most of the water available is in the form of seas and oceans characterized by high concentrations of salt. It is therefore unsuitable for human, agricultural and even industrial use. Water that is concentrated in ice poles or in many water surfaces such as

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rivers or located in rock cracks at a depth of up to 800 meters below ground represents freshwater, but its percentage does not exceed 2.98%. Despite this small percentage, what is available for use of this freshwater for humans is not more than 0.3%. The world today faces many problems related to the inability to access clean water, especially after the large population growth and industrial development, where 1.2 billion People lack access to safe drinking water. 2.6 billion People have access to only a little of this water or have no sewage networks. More than 80% of the world's diseases are directly caused by water pollution or lack of adequate availability for washing or other household uses. Millions of deaths have been recorded every year for the same reason, and 3,900 children die every day from water-borne diseases or the intermingling of drinking water with wastewater [1, 2].

In order to reduce the pollution of what remains to be used of this wealth, and in order to deliver safe and non-polluted water to citizens, water specialists have constructed and developed water treatment systems, which are becoming more complex and costly as pollutants become more concentrated in water. Water purification plants are the main artery from which the cities are supplied, especially large ones, with water from the public water network, and it is one of the least complex water treatment systems. However, the use of this water in a safe and healthy manner is not possible until the plants have fulfilled their tasks in the treatment of water from the water source. The greater the concentration of pollutants and salts in water, the less likely it is to treat this water in one single stage. Therefore, it is necessary to use multiple stages where sophisticated water treatments may be needed to remove undesirable substances. Therefore, the energy needed for treatment is directly proportional to the salt content [3].

The purification plants consist of many units, the most important of which are sedimentation basins and sand filters, as well as rapid mixing tanks and slow mixing basins that increase the efficiency of sedimentation. Sediments removal efficiency after initial normal sedimentation units is usually 45-60% for suspended solids and 40-60% for total E-coli bacteria. The sediment removal efficiency after the sedimentation units on addition of auxiliary chemicals between 60-80% for suspended solids and 60-90% for total E-coli bacteria. Filters units remove the remaining granular impurities and remove 80% of the bacteria and algae, iron and manganese as well as improving the taste and odor [4].

In order to know the effectiveness of the purification plants to remove impurities and suspended solids, the efficiency of treatment of the water discharged from these plants should be determined. This is done by carrying out laboratory analyses for various parameters before and after water treatment. The more the parameters measured, the more comprehensive and clearer the working system of the purification plant. The aim of the research may thus be summarized as follows:

1- To compare and assess the quality and efficiency of water produced from four purification plants.
2- To determine the extent of compliance of the produced water to the specifications of Iraq, the United States, and the World Health Organization.
3- To determine the feasibility of implementing changes in the system of water purification plants in Basrah with the current changes in water quality.

2. MATERIALS AND METHODS

2.1 Sampling and Analysis Sites

Samples of raw water and treated water were collected from four water purification plants. They were located in different areas in Basrah Governorate namely AL-Medayna plant (source of water is the Euphrates River), Al-Hartha plant, Al-Jubaila, and Al-Bardeya. The latter three plants have their source of water from the Tigris River mixed with little quantities of Euphrates River as shown in Fig. 1. Three plants are in the center of the province and the fourth is located north of the province. Samples were collected in triplicate and stored in clean and sealed plastic bottles. The physical and chemical properties to be measured for the studied samples [5] are electrical conductivity (EC), pH (pH), turbidity (Turb), total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), magnesium (Mg), calcium (Ca), sodium (Na), chlorine (Cl), and potassium (K). The study lasted for 6 months starting in November 2017, until April 2018. Each month, water samples were taken once and the tests were conducted to determine the concentrations of the above parameters. The overall removal efficiency of each parameter is obtained by comparing the values obtained for raw water and treated water for the four plants. The efficiency of removal is obtained from Eq. (1) [6]:

Fig. 1. A map of the study areas start from the Euphrates and Tigris and till the last plant of the Shatt al-Arab.

$$Efficiency\ of\ removal\ (E\%) = 100 \times \frac{C_{in} - C_{out}}{C_{in}} \quad (1)$$

Where C_{in} is concentration of raw water samples and C_{out} is the concentration of treated water samples.

The statistical analysis of the various parameters for the studied samples was performed using two-Way ANOVA for (SPSS V.15.). The efficiency of the treatment was determined by Paired Samples T test and Wilcoxon Test [7, 8].

3. RESULTS AND DISCUSSION

3.1 Rates of Dissolved Solids and Discharges of Rivers Water

Figure 2 shows the concentrations of dissolved solids in different areas of the province over the last ten years starting from the Al-Qurna, which feeds from the Tigris

River, and then Al-Medayna, and then the center of Shatt al-Arab, and the area of Abi Al-Khasib and area of Seihan. The Seihan area is the closest to the Gulf.

It is seen from Fig. 2 that salt concentrations in the five regions from which the data were taken over the last 10 years, decreased slightly in salinity but returned to the same or slightly lower levels of previous years. This indicates the stability and non-change of high concentrations of salt during the ten years exceeding the limits allowed in the approved specifications of drinking water, without recording a marked drop in them [9].

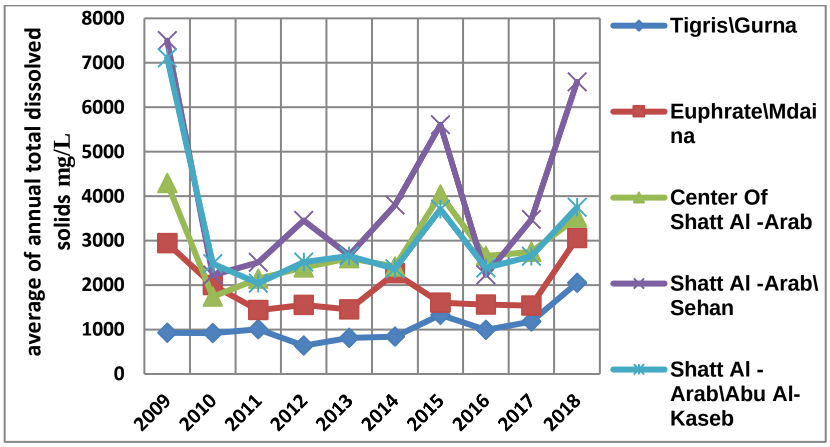

Fig. 2. Annual salts concentration curve in mg /L for different locations of the governorate for the last ten years [9].

All of the water concentrations over the ten years period were much higher than the maximum permissible drinking standards of 1000 mg /L [10], except for Al-Qurna site, which is fed directly from the Tigris River, which lies 70 km north of the center of the province. It was close to the maximum limits of specifications.

Figure 3 shows the annual rates of discharge of two areas: one within the administrative boundaries of Amara province, and the other on the administrative border of Basrah province. It is clear that the annual discharge rate over the last ten years up to 2018, ranged between 34-60 m^3/s at the border of the northern province of Basrah. The total water discharge rate for the study period was 49 m^3/s [9], and thus did not reach, at the center of Shatt al-Arab, the minimum discharge rate required of 75 m^3/s to maintain the salinity below 2000 mg/L [11]. The minimum rate would have limited the deterioration of the water quality that supplies the population of Basrah. This rate was not reached even at the administrative border with other neighboring provinces, which are at least 70 km north of the Shatt al-Arab center.

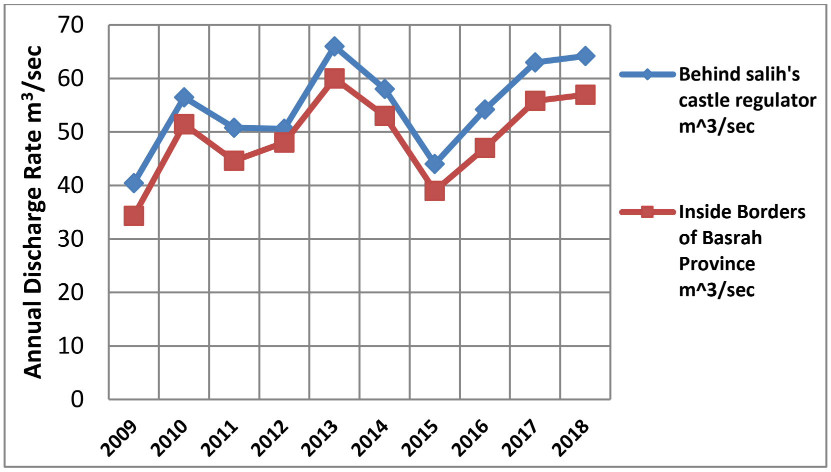

Fig. 3. Annual rate of discharge, m^3/s in different locations for the last ten years [9].

It is clear from the recorded data that there is stability and no changes in the high salt concentrations and it has not recorded a significant decrease. The concentration of salts were much higher than the maximum limits of approved drinking water specifications. The discharges of water from the Tigris and Euphrates Rivers, which feed together the Shatt al-Arab waters and the center of the province with water of moderate quality, did not reach even the minimum limits recommended [11].

3.2 Physical and Chemical Properties Taken for the Studied Plants

3.2.1 Temperature (T)

The temperature at the time of the laboratory tests was recorded at an average of 19.62°C and the highest was recorded at 22.70°C, while the lowest was 15.15°C.

3.2.2 PH

Most of the collected samples were within the limits of the approved specifications of drinking water. The highest value was recorded at Al-Medayna plant at 8.07 while the lowest value was 6.46 at the same plant.

3.2.3 Electrical conductivity (EC)

The highest value of raw water EC for the four plants, was recorded at plant (D) Al-Bradeya with a concentration of 7.62 dS/m while the lowest concentration for raw water was recorded at 2.65 dS/m in plant (A) Al-Medayna. Plant (D) had the highest concentration of treated water at 7.81 dS/m, while the lowest concentration was at plant (A) at 2.65 dS/m. Statistical analysis showed significant differences between the plants and between the months of the study. No significant differences were recorded before and after treatment for EC. Plant (C) recorded the highest overall efficiency compared with the rest of the studied plants at 11.76%. Plant (B) recorded the lowest efficiency of 0.37%. In general, the EC treatment efficiency at the plants was very low, and some of the reasons for the low efficiency are due to the high salts concentrations of the raw water.

3.2.4 Total dissolved solids (TDS)

The highest TDS for raw water in the four plants was recorded at plant (D) Al-Bradeya at 3810 mg /L while the lowest TDS was 1330 mg/L at plant (A) Al-Medayna. Plant (D) recorded the highest concentration of treated water at 3900 mg/L and the lowest TDS was at plant (A) at 1330 mg/L. Statistical analysis showed significant differences between the plants and between the months of the study. No significant differences were recorded between the samples before and after treatment. Plant (C) recorded the highest overall efficiency at 12.20% while plant (B) recorded the lowest efficiency of 0.37%. The TDS treatment efficiency of the plants was very low, and none of the samples treated were within the limits of approved drinking water specifications. In general, it is noted that the higher the concentration of salts in raw water, the more likely that the plants' ability to process will be weakened. It is recommended [3-12] that more progressive and complex techniques be used if the saline concentrations of water exceed 1200-1500 mg/L. It is obvious that one plant may surpass the other in the technical and operational aspects on increased salt concentration. Increased concentration of dissolved salts in water adversely affects the performance of purification units, as it quickly causes damage and corrosion of machines, pumps, units and pipes and increases the burden on the impurities treatment process. Increased salt concentration in water also reduces the effect of auxiliary chemicals such as alum on sedimentation and conversion to other chemical compounds, and increases the concentrations of pollutants to be treated, and damages the medium of sand filters. Therefore, there is a need for replacement and maintenance of the purification units in short periods [3-13]. Table 1 shows the parameters concentrations and treatment efficiency for the plants samples during the study period [14-16].

3.2.5 Turbidity (Turb)

The highest Turb in raw water was recorded at plant (B) Al-Hartha with 91.10 NTU, while the minimum concentration was 1.89 NTU at plant (A) Al-Medayna. Plant (B) recorded the highest concentration of treated water at 120.00 NTU, while the lowest concentration was at plant (A) with 3.01 NTU. There were significant differences between the months of the study, and the statistical analysis showed significant differences between the plants. No significant differences were recorded for Turb between the samples before and after treatment. Plant (A) showed the highest overall Turb efficiency at 13.34% and plant (B) recorded the lowest efficiency at 3.88%. The efficiency of Turb treatment was insufficient, there were only 4 samples within the limits of approved drinking water specifications.

3.2.6 Total suspended solids (TSS)

The results showed that the highest raw water TSS was recorded at plant (B) Al-Hartha with a concentration of 434.00 mg/L, while the lowest recorded concentration was 132.00 mg/L at plant (C) Al-Jubaila. Plant (B) recorded the highest TSS concentration of treated water at 428.00 mg/L while the lowest concentration was at plant (C) at 131 mg/L. Statistical analysis showed significant differences between the plants and between the months of the study. No significant differences were recorded between the samples before and after treatment. Plant (A) recorded the highest overall efficiency at 13.35% while plant (B) recorded the lowest efficiency at 3.91%. The efficiency of TSS treatment was very low. None of the treated samples were within the limits of approved drinking water specifications. This is because the purification units and sand filters were not cleaned periodically and they remained for long periods without cleaning. When alum was added to the basins, the water was not left for a suitable sedimentation period. The water comes out directly from the basins which increases the impurities in the produced water. The high concentration of TSS in raw water is due to the mixing of sea water with river water; wastewater is also drained along the river.

3.2.7 Total hardness (TH)

The highest TH of raw water was recorded at plant (B) Al-Jubaila at a concentration of 3480 mg/L while the lowest concentration was 1070 mg/L at plant (A) Al-Medayna. Plant (B) recorded the highest concentration of treated water at 3500 mg/L while the lowest concentration was in plant (D) at value of 710.00 mg/L. Statistical analysis showed significant differences between plants and between the months of the study. No significant differences have been recorded between the samples before and after treatment except in plant (D) Al-Bradeya. Plant (D) has the highest overall efficiency at 16.16%, while plant (B) has the lowest efficiency of 0.66%. The ratio of total treatment efficiency was very low, and the high TH in raw water is due to the mixing of sea water with river water. Wastewater is also drained along the river. None of the treated specimens were within the limits of the approved drinking water specifications.

3.2.8 Calcium (Ca)

The results showed that the highest Ca concentration of raw water was recorded at plant (B) Al-Jubaila at 252 mg /L, while the lowest concentration was recorded at 168 mg /L at plant (A) Al-Medayna. Plant (B) recorded the highest Ca concentration of treated water at 252 mg/L and the lowest concentration was at plant (A) at 148.00 mg /L. Statistical analysis showed significant differences between the plants and between the months of the study. No statistically significant differences were seen between the samples before and after treatment except in plant (D). Plant (D) recorded the highest percentage of total efficiency compared to the other plants at 9.33% while plant (B) recorded the lowest efficiency of 2.08%. The overall treatment efficiency was very low, and none of the treated samples were within the limits of approved drinking water specifications.

3.2.9 Magnesium (Mg)

The results showed that the highest Mg concentration in raw water was at (B) plant at 144.94 mg/L while the lowest concentration was 29.28 mg/L at (A) Al-Medayna plant. Plant (B) recorded the highest concentration of treated water at 143.96 mg/L and the lowest concentration was at plant (D) at 9.27 mg/L. The statistical analysis showed that there were significant differences between the plants and between the months of the study. No significant differences were recorded between the samples before and after treatment. Plant (D) recorded the highest efficiency at 21.01% while plant (B) recorded the lowest efficiency of 0.11%. The overall Mg treatment efficiency was very low. Only 10 samples were within the limits of approved drinking water specifications.

3.2.10 Chloride (Cl)

The results showed that the highest Cl concentration of raw water was recorded at Al-Hartha plant (B) at 1302.85 mg/L while the lowest Cl concentration was 454.40 mg /L at Al-Medayna plant (A). Plant (C) recorded the highest concentration of treated water with a Cl concentration of 1526.50 mg /L and the lowest Cl concentration was at plant (A) at 457.95 mg/L. The statistical analysis showed significant differences between the plants and between the months. No significant differences were observed before and after treatment except in plant (D). Plant (A) recorded the highest overall efficiency at 14.62% while plant (B) recorded the lowest efficiency of 0.10%. The overall efficiency of treatment was very low, and none of the treated specimens were within the limits of approved drinking water specifications.

3.2.11 Sodium (Na)

The highest value of Na concentration in the raw water was recorded at Al-Bradeya plant (D) at 635.90 mg/L while the lowest Na concentration was 303.30 mg/L at Al-Medayna plant (A). The highest Na concentration of treated water was recorded at plant (B) at 631.20 mg /L and the lowest concentration was in plant (A) at 305.40 mg/L. The statistical analysis showed significant differences between the plants. No significant differences were observed between the study months and between the samples before and after treatment except in plant (D). Plant (C) recorded the highest overall efficiency at 9.09% and plant (B) recorded the lowest efficiency of 1.13%. The overall treatment efficiency was very low, and none of the treated specimens were within the limits of approved drinking water specifications.

3.2.12 Potassium (K)

The highest value of K concentration in the raw water has been recorded at Al-Hartha plant (B) at 26.10 mg/L while the lowest concentration was 8.80 mg/L at Al-Medayna plant (A). Plant (B) recorded the highest K concentration of treated water at 26.40 mg /L while the lowest concentration was at plant (A) at 9.10 mg L. The statistical analysis showed that there were statistically significant differences between the plants. No significant differences were evident between the study months or between the samples before and after treatment. Plant (C) recorded the highest overall efficiency at 12.31%, while plant (B) recorded the lowest efficiency of 1.14%. The overall treatment efficiency was very low, and there were only 6 samples within the limits of approved drinking water specifications [17].

Table. 1. Parameters concentrations and removal efficiency for plants samples.

Plant	Month	Sample	pH	T, °C	EC, ms	TDS, mg/l	Turbidity NTU	TSS, mg/l	TH, mg/l	Ca, mg/l	Mg, mg/l	Cl, mg/l	Na, mg/l	K, mg/l
Al- Medyna	November	A1	6.46	19.6	2.65	1330	1.89	384	2100	176	81.01	454.4	303.3	8.8
		A2	6.56	19.5	2.65	1330	3.01	410	2140	180	83.45	457.95	305.4	9.1
	Efficiency %		-	-	0	0	-0	-0	-0	-0	-0	-0	-0	-0
	December	A1	6.83	15.3	3.32	1697	3.73	391	2580	192	102.48	674.5	402	12.8
		A2	7.73	15.7	3.32	1667	3.34	350	2500	168	101.5	628.35	381.90	12
	Efficiency %		-	-	0	1.77	10.46	10.49	3.1	12.5	0.95	6.84	5	6.25
	January	A1	7.24	19.4	5.76	2880	14.53	283	2940	176	122	823.6	481	16.6
		A2	7.79	19.4	3.65	1821	8.53	166	2240	148	91.26	497	329.2	9.4
	Efficiency %		-	-	36.63	36.77	41.27	41.34	23.81	15.91	25.2	39.66	31.56	43.37
	February	A1	7.53	21.1	5.29	2650	11.73	183	1250	168	40.5	717.1	343.5	10.3
		A2	5.54	20.8	5.5	2760	13.08	203	1230	176	38.55	710	337.3	11
	Efficiency %		-	-	-0	-0	-0	-0	1.60	-0	4.82	0.99	1.80	-0
	March	A1	7.55	22.3	4.02	2010	8.86	276	1380	172	46.36	855.55	368.4	14
		A2	7.58	22.3	3.31	1654	6.35	198	1150	180	34.16	880.4	370.9	14
	Efficiency %		-	-	17.66	17.71	28.33	28.26	16.67	-0	26.32	-0	-0	0
	April	A1	7.73	20.5	3.28	1636	6.9	231	1070	188	29.28	1057.9	360.3	9.9
		A2	8.07	20.8	3.42	1713	38.8	236	1300	184	40.99	631.9	383.1	10.5
	Efficiency %		-	-	-0	-0	-0	-0	-0	2.13	-0	40.27	-0	-0
	Total efficiency %		-	-	9.05	9.08	13.34	13.35	7.53	5.09	9.55	14.62	6.39	8.27
	Average of total removal ratios%								**10.20**					
Al- Hartha	November	B1	7.69	20.6	6.28	3130	25.18	374	2400	252	86.38	1302.85	568.6	21.7
		B2	7.78	20.4	6.28	3130	33.18	386	3360	252	133.22	1309.95	617.5	26.4
	Efficiency %		-	-	0	0	-0	-0	-0	0	-0	-0	-0	-0
	December	B1	7.69	15.5	5.46	2730	57.65	434	3420	224	139.57	1118.25	627.8	26.1
		B2	7.75	15.7	5.46	2730	56.89	428	3500	224	143.47	1164.4	631.2	26.2
	Efficiency %		-	-	0	0	1.32	1.38	-0	0	-0	-0	-0	-0
	January	B1	8	15.8	5.44	2720	33.6	384	3480	204	144.94	1146.65	578.7	21.7
		B2	8.04	15.8	5.37	2690	33.09	378	3500	220	143.96	1139.55	571.2	21.7
	Efficiency %		-	-	1.29	1.1	1.52	1.56	-0	-0	0.67	0.62	1.3	0
	February	B1	7.6	21	7.19	3600	3.82	258	1520	224	46.85	820.05	433.1	17.6
		B2	7.61	21.2	7.12	3560	3.04	205	1460	196	47.34	994	412.8	16.6
	Efficiency %		-	-	0.97	1.11	20.42	20.54	3.95	12.5	-0	-0	4.69	5.68

Table. 1. Parameters concentrations and removal efficiency for plants samples, (Cont.).

Plant	Month	Sample	pH	T, °C	EC, ms	TDS, mg/l	Turbidity NTU	TSS, mg/l	TH, mg/l	Ca, mg/l	Mg, mg/l	Cl, mg/l	Na, mg/l	K, mg/l
Al- Hartha	March	B1	7.5	22.7	4.51	2250	91.1	248	1400	184	45.87	969.15	394.6	16
		B2	7.48	22.3	5.07	2540	120	268	1580	252	46.36	1171.5	448.9	19
	Efficiency %		-	-	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
	April	B1	7.3	20.8	5.08	2540	35.8	224	1600	216	51.73	1065	538.6	17.4
		B2	7.37	20.4	5.15	2580	44.4	227	1730	224	57.1	1079.2	534.3	17.2
	Efficiency %		-	-	-0	-0	-0	-0	-0	-0	-0	-0	0.8	1.15
	Total efficiency %		-	-	0.37	0.37	3.88	3.91	0.66	2.08	0.11	0.10	1.13	1.14
	Average of total removal ratios%								**1.38**					
Al-Jubaila	November	C1	7.67	20.6	4.94	2470	41.73	242	3000	228	118.58	1004.65	547.2	19.9
		C2	7.75	21.5	3.07	1532	26.08	151	2300	176	90.77	568	371.3	12.6
	Efficiency %		-	-	37.85	37.98	37.5	37.6	23.33	22.81	23.46	43.46	32.15	36.68
	December	C1	7.64	16.3	4	2090	22.13	328	2740	208	108.34	795.2	465.9	16.5
		C2	7.59	16	2.95	1477	17.52	260	2340	184	91.74	603.5	393.3	13.2
	Efficiency %		-	-	26.25	29.33	20.81	20.73	14.6	11.54	15.32	24.11	15.58	20
	January	C1	7.08	19.4	5.98	2990	11.76	203	3000	200	122	880.4	443.3	17.1
		C2	7.36	19.3	5.75	2880	12.03	207	2900	196	117.61	887.5	413.1	15.6
	Efficiency %		-	-	3.85	3.68	-0	-0	3.33	2	3.6	-0	6.81	8.77
	February	C1	7.35	21.1	6.87	3440	2.38	252	1320	172	43.43	923	376.6	14.3
		C2	7.17	22.1	7.16	3580	3.97	333	1520	224	46.85	1001.1	440.3	19.7
	Efficiency %		-	-	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0
	March	C1	7.35	21.4	5.43	2710	53.1	318	1710	236	54.66	1235.4	467.8	23.7
		C2	7.27	21.9	5.29	2650	50.16	300	1600	232	49.78	1526.5	579.4	21.7
	Efficiency %		-	-	2.58	2.21	5.54	5.66	6.43	1.69	8.93	-0	-0	8.44
	April	C1	7.11	20.9	5.27	2640	13.3	132	1510	200	49.29	1157.3	589	22.3
		C2	7.06	18.2	5.31	2650	13.2	131	1560	216	49.78	1171.5	619.6	23.8
	Efficiency %		-	-	-0	-0	0.75	0.76	-0	-0	-0	-0	-0	-0
	Total efficiency %		-	-	11.76	12.2	10.77	10.79	7.95	6.34	8.55	11.26	9.09	12.31
	Average of total removal ratios%								**10.10**					

Table. 1. Parameters concentrations and removal efficiency for plants samples, (Cont.).

Plant	Month	Sample	pH	T, °C	EC, ms	TDS, mg/l	Turbidity NTU	TSS, mg/l	TH, mg/l	Ca, mg/l	Mg, mg/l	Cl, mg/l	Na, mg/l	K, mg/l
Al-Bradeya	November	D1	8	19.4	4.79	2400	38.45	392	3020	236	118.58	940.75	527.1	19.2
		D2	8.02	19.2	4.39	2190	37.11	378	2840	196	114.68	887.5	490.7	17
	Efficiency %		-	-	8.35	8.75	3.49	3.57	5.96	16.95	3.29	5.66	6.91	11.46
	December	D1	7.48	16.5	3.61	1807	33.2	306	2640	200	104.43	688.7	438.9	14.7
		D2	7.65	16.9	3.34	1670	26.61	245	2580	180	103.94	639	410.8	13.1
	Efficiency %		-	-	7.48	7.58	19.85	19.93	2.27	10	0.47	7.22	6.40	10.88
	January	D1	7.29	18.8	5.52	2760	12.88	211	2880	184	118.1	830.7	398.1	15.7
		D2	7.51	18.8	4.59	2290	10.03	164	2660	160	110.29	656.75	344.1	11.2
	Efficiency %		-	-	16.85	17.03	22.15	22.27	7.64	13.04	6.61	20.94	13.56	28.66
	February	D1	7.28	21.2	7.62	3810	5.13	210	1650	200	56.12	1178.6	454.7	21.3
		D2	7.45	21.3	7.81	3900	12.46	251	1470	200	47.34	1093.4	467.9	22.2
	Efficiency %		-	-	-0	-0	-0	-0	10.91	0	15.65	7.23	-0	-0
	March	D1	7.31	20.6	5.37	2690	52	270	1880	228	63.93	1199.9	588.1	22.4
		D2	7.46	21.5	5.35	2580	51.68	268	1550	200	51.24	1185.7	565.9	21.6
	Efficiency %		-	-	4.28	4.09	0.62	0.74	17.55	12.28	19.85	1.18	3.77	3.57
	April	D1	7.3	18.9	5.34	2670	12.5	218	1500	216	46.85	.199.9	635.9	24
		D2	7.13	20.9	4.88	2560	11.42	199	710	208	9.27	.143.1	605.6	21.8
	Efficiency %		-	-	4.12	4.12	8.64	8.72	52.67	3.70	80.21	4.73	4.76	9.17
	Total efficiency %		-	-	6.84	6.93	9.12	9.20	16.16	9.33	21.01	7.83	5.90	10.62
	Average of total removal ratios%								**10.29**					
The Limits of Iraq, EPA, and WHO Specifications			6.5*-8.5*	-	-	1000*	5*	0*	500*	50*	50*	200*	200*	12**
Number of treated samples and conformed to specifications			23	-	0	0	4	0	0	0	10	0	0	6
The least significant difference at 0.05	Plants		-	-	0	0	0	0.022	0.00	0.00	0.002	0.00	0.00	0.00
	Months		-	-	0	0	0	0	0	0.04	0	0.01	0.06	0.61
	Before and After Treatment	A_1 A_2	-	-	0.31	0.30	0.49	0.25	0.38	0.41	0.42	0.17	0.38	0.43
		B_1-B_2	-	-	0.44	0.43	0.18	0.65	0.22	0.45	0.27	0.11	0.38	0.28
		C_1-C_2	-	-	0.2	0.19	0.23	0.56	0.24	0.86	0.15	0.71	0.79	0.53
		D_1-D_2	-	-	0.09	0.09	0.68	0.3	0.04	0.02	0.08	0.02	0.03	0.06

These symbols mean: (A_1, B_1, C_1, D_1,):Raw water samples which is entering to the studied plants, (A_2, B_2, C_2, D_2,): Treated water samples which is exiting from the studied plants.
*:[14-15-16]. , ** : [17].

4. CONCLUSIONS

1- The results showed that the efficiency of water treatment was very low in the four plants. The efficiency varied and the quality of the water produced from the plants was not commensurate with the large sums spent on the process.

2- It is seen that the Al-Hartha plant recorded the lowest treatment efficiency, which indicates deteriorated operation. The average removal ratios of all the parameters in this plant was 1.38% while Al Bradeya plant recorded the highest removal ratios at 10.29%, followed by Al-Medayna plant at 10.20%, and Al-Jubaila plant by 10.10%.

3- Laboratory tests showed that the samples from the Al-Bradeya plant recorded the lowest percentage of negative samples followed by the Al-Jubaila plant, then Al-Medayna. Al-Hartha plant was the plant that had recorded the most negative samples.

4- Although the results showed that 23 samples of the treated samples were within the specifications limits of pH, 4 samples of the turbidity were within the specifications, 6 for K, and 10 for Mg, not a single record showed conformity to the specifications for EC, TSS, TDS, Cl, Na, TH, and Ca. It may thus be concluded that the treated water samples from all four plants are unsuitable for drinking uses.

5- The fault was not only in the inability of the plants to treat dissolved salts in water, but there was a deficiency in the ability of plants to remove impurities and suspended solids.

6- Although TSS concentrations in the Al-Medayna plant were lower than at Al-Jubaila and Al-Bradeya plants, which is supposed to improve their treatment capacity, the overall efficiency of the parameters at the three plants remained close, and Al-Bradeya plant exceeded the other two plants, albeit with a small margin due to technical, operational, and design factors.

7- It is noted that the higher the concentration of dissolved solids in the water, the lower the capacity of the purification plants to treat the water. This was recorded at the Al-Modayna and Al-Bradeya plants. Although the Al-Bradeya plant was better than the

Al-Modayna plant in operational and technical aspects, and this is evident from the total removal ratios of 10.29%, 10.10%, Al-Modayna plant surpassed Al-Bradeya in a low concentration of dissolved solids in water, recording the highest removal ratio at 9.08%, while the Al-Bradeya recorded 6.93%.

8- It is clear from the rates of discharge over the ten years study period feeding Shatt al-Arab from the river water at the center of the province, that it is insufficient to contribute to a positive change in the quality of water. Also, salt concentrations always recorded a large rise and relative stability in this rise that exceeded maximum approved specifications limits. This negatively affects the efficiency of treatment in the purification plants and makes them unable to cope with the deterioration in water quality. Decreasing salinity by introducing auxiliary factors will improve the efficiency in the near and medium future.

In order to make use of the previous points from a practical point of view, the following basic recommendations are suggested:

- Periodic cleaning of purification units, especially sedimentation tanks and sand filters.
- In plants where the influent TSS concentration is too high it is recommended to use auxiliary chemicals in the sedimentation tanks.
- To achieve high removal efficiency of suspended solids when adding alum, water should be left in the tanks for at least 2-4 hours before exiting in order to avoid adding other impurities to the treated water instead of reducing them [6-18].
- To treat the high salinity of the water source in Basra, desalination technology should be used in the treatment plants. Water should pass through the primary treatment unit, which is the purification plant, and then transferred to the desalination units.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

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كفاءة معالجة بعض محطات التصفية في محافظة البصرة وتأثرها بتغاير نوعية المياه

تم اجراء اختبارات معملية لتقييم كفاءة المعالجة لمحطات تصفية المياه ومدى تأثرها بتغيرات مياه الانهار في أربع محطات في محافظة البصرة، حيث تم قياس بعض الخصائص الفيزيائية والكيميائية. لقد بينت نتائج الدراسة أن جودة وكفاءة المياه المعالجة كانت قليلة جداً وغير مقبولة في المحطات الاربعة، حيث سجلت محطة الهارثة أدنى كفاءة معالجة عامة بنسبة ١,٣٨%، بينما سجلت محطة البراضعية أعلى معدل كفاءة عامة ١٠,٢٩%. كما بينت الدراسة أن عينات المياه المعالجة للمحطات غير صالحة الاستخدام للشرب، كما بينت النتائج أن الخلل في تدني كفاءة المعالجة لم يكن فقط في عدم قدرة المحطات على معالجة الاملاح الذائبة في الماء بل كان هناك خلل كبير في قدرة المحطات على ازالة الشوائب والمواد العالقة وهو ما يندرج في جوهر عمل ومهام المحطات. ولقد بينت الدراسة أن معدلات التصاريف وتركيزات الاملاح خلال العشر سنوات الاخيرة المغذية لشط العرب من الانهار كانت غير كافية لتسهم في تغير ايجابي على نوعية المياه، وبالتالي ينبغي اعتماد تقنية اكثر تطوراً من تصفية المياه وهي التحلية في عموم محطات البصرة بحيث تكون تحلية المياه هي مكملة ولاحقة لعملية التصفية.